## REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson 1210, Authority (No. 2220-2402), and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

	12-4302, and to the Office of Management and B		
1. AGENCY USE ONLY (Leave black	i i	3. REPORT TYPE AND	DATES COVERED
	6 May 1996	Final Report	5. FUNDING NUMBERS
4. TITLE AND SUBTITLE	tion of Sound Wave Scat	ttoring from a	G N00014-92-J-1432
=	nd Acoustic Reconnaissa	-	G N00014-92-3-1432
Analysis	nd Acoustic Reconnaisse	ince Data	
5. AUTHOR(S)			
George V. Frisk and D	ajun Tang		
S	3 0		
. PERFORMING ORGANIZATION N	IAME(S) AND ADDRESS(ES)		8. PERFORMING ORGANIZATION REPORT NUMBER
YI - 1 - II - 1 - 0	1. 1		
Woods Hole Oceanograph Woods Hole, MA 02543			
woods Hole, MA 02545			
S. SPONSORING/MONNORING AG	ENCY N		SPONSORING / MONITORING
. 31 0315 0 mm 3 / m 5 m 7 0 m 7 5 m 7 5		ALL APA	AGENCY REPORT NUMBER
	1000	ለጠ4 በኡራ	
	10067	HKI UNU	
	19901	031 056	
	1000.	•••	
	TOTAL STATE OF THE PARTY.	entre, annother attacher - abordon a daleit fan daleit inde yn eintre homen ein filige.	The state of the s
1. SUPPLEMENTARY NOTES			
The theorectial forma	lism of the Scattering	Correlation Coe	fficient (SCC) was complet
			Society of America, Tang a
Frisk, 92 (5), 2792-2	799 (1992).	(Designation of the contraction	126. DISTRIBUTION CODE
128. DISTRIBUTION / AVAILABILITY	STATEMENT		IZD. BISTRIEU GON CODE
	1		
Approved for public	release; distribution	is unlimited	
		441703 e	K. T. N. Commission
13. ABSTRACT (Maximum 200 wor	where the $\mathcal{L}_{\mathcal{A}}$ is the second contract of the second contra	understallt der Later (1994 - 1923) – Sett 1981 – Liver (1995 – 1995) – 1985 – Liver Later (1995) – 1985 – 1985	168336 3 3
	he grant was to develop		
			bottom scattering and to
analyze some of the 1	991 ARSRP reconnaissan	ce experiment da	ta obtained in the sedimen
pond.			
			on understanding the data
set near a sediment p	ond area. Because the	environment sur	rounding this pond was ver
complicated, and the	acoustic source/receiv	er array respons	es have complicated struc-
tures, we proceeded b	y isolating individual	effects and com	paring the scattered signa
			y the same incident and
			and backward-looking beam
			the ARSRP 1991 reconnais-
sance cruise were ext		o and lyy llom	one implication and incommutation
		ced a spectral n	arameterization which is
			cean bottom. Unlike the
	-		omain, the SCC, is defined
the wavenumber domain		TIL TILE OPACIAL W	15. NUMBER OF PAGES
TA. SUBJECT TERMS			15. NUMBER OF PAGES  2
Scattering correl	ation coefficient (SCC)	), bottom scatte	ring l
<b>62</b>	•		16. PRICE CODE
	ng green diction to the control of t		CANCEL TO LIBRITATION OF BECTER
17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIF	ų.
			Unlimited
Unclassified	Unclassified	Unclassified	

Woods Hole Oceanographic Institution Woods Hole, MA 02543

May 6, 1996

Dr. Jeffrey Simmen CODE 321 OA Office of Naval Research Ballston Tower One 800 N. Quincy ST. Arlington, VA 22217-5660

Dear Jeff,

Enclosed please find the final report of the Grant "Spectral parameterization of sound wave scattering from a random ocean bottom and acoustic reconnaissance data analysis," Grant N00014-92-J-1432.

Sincerely,

Dajun Tang

Distribution:
R. Tanner, Administrative Grants Officer
Director, NRL
Defense Technical Information Center

cc: Ann Henry WHOI Grants and Contracts

## Final Technical Report Spectral Parameterization of Sound Wave Scattering from a Random Ocean Bottom and Acoustic Reconnaissance Data Analysis Grant N00014-92-J-1432

George V. Frisk and Dajun Tang Woods Hole Oceanographic Institution Woods Hole, MA 02543 (508) 289-2499 FAX (508) 457-2194 email: gfrisk@whoi.edu; dtang@whoi.edu

The objectives of the grant was to develop a new concept called the Scattering Correlation Coefficient (SCC) to characterize low-frequency bottom scattering and to analyze some of the 1991 ARSRP reconnaissance experiment data obtained in the sediment pond. This research was started under the background that bottom scattering had been receiving increased attention. The ONR sponsored ARSRP reconnaissance experiment produced large amounts of bottom scattering data near the Mid-Atlantic Ridge area, where the bottom features range from mid-ocean ridges to sediment ponds. These data therefore provided an opportunity to investigate the scattering characteristics of different bottom types. In conjunction with the data analysis, the issue of quantifying the bottom scattering process needed to be addressed. The conventional method of characterizing bottom scattering is based on the classical concept of scattering cross section. This concept is typically developed in the context of wave propagation in a medium that is homogeneous except for a small region (the scattering region) where the physical properties, e.g., sound speed or density in acoustics or refractive index in electromagnetics, are different from those in the surrounding medium. In underwater acoustics, a quantity which is frequently used to parameterize volume scattering is an outgrowth of this classical framework and is defined as the volume scattering cross section. This parameter was inadequate to quantify low-frequency bottom scattering because of multipath and refraction effects. Therefore, a new method to quantify this interaction was required.

In the data analysis part of our work, we concentrated on understanding the data set near a sediment pond area. Because the environment surrounding this pond was very complicated, and the acoustic source/receiver array responses have complicated structures, we proceeded by isolating individual effects and comparing the scattered signals due to the sediment with those due to rocky areas at exactly the same incident and scattering angles. We accomplished this by using forward- and backward-looking beam signals with the same beam angles. Pings 198 and 199 from the ARSRP 1991 reconnaissance cruise were extensively examined.

For the modeling part, we have introduced a spectral parameterization which is suitable for describing acoustic scattering from a random ocean bottom. Unlike the



scattering cross section, which is defined in the spatial domain, the SCC is defined in the wavenumber domain. Assume that scatterers are randomly distributed on and beneath the water/bottom interface, both the incident wave and scattered waves are expanded as plane wave superpositions. The theoretical formalism of the Scattering Correlation Coefficient (SCC) was completed and the result has been published in a paper (Tang and Frisk, "Spectral parameterization of scattering from a random ocean bottom," J. Acoust. Soc. Am., 92 (5), 2792-2799, 1992).

The funds were spent according to the budget on salary and travels, plus the purchase of a workstation to support the data analysis.